Eighteenth meeting of the International Committee on Global Navigation Satellite Systems, Wellington, New Zealand

7 – 11 October 2024

JOINT STATEMENT

1. The eighteenth meeting of the International Committee on Global Navigation Satellite Systems (ICG) was held in Wellington from 7 to 11 October 2024 to continue reviewing and discussing developments in the field of global navigation satellite systems (GNSS) and to allow ICG members, associate members and observers to address recent developments in their countries, organizations and associations regarding GNSS services and applications.
2. Honourable Chris Penk, Minister for Land Information, New Zealand, and Amy Guihot, Australian Deputy High Commissioner, delivered opening statements. Sharafat Gadimova, on behalf of the executive secretariat of ICG and the Office for Outer Space Affairs, also addressed the meeting.
3. The meeting was held with in-person and online attendance by representatives of Algeria, Australia, China, India, Italy, Japan, Malaysia, New Zealand, Republic of Korea, Russian Federation, United Arab Emirates, United States of America and European Union, as well as the following intergovernmental and non-governmental organizations: Civil Global Positioning System Service Interface Committee, European Space Agency, International Association of Institutes of Navigation, International Bureau of Weights and Measures, International Earth Rotation and Reference Systems Service, International Federation of Surveyors, International Association of Geodesy, International GNSS Service, International Union of Radio Science, International Telecommunication Union and Radio Technical Commission for Maritime Services. Representative of the Office for Outer Space Affairs also participated.
4. Representatives of Norway, Pakistan, the United Kingdom of Great Britain and Northern Ireland, the Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP, India), the Regional Centre for Space Science and Technology Education in Asia and the Pacific (RCSSTEAP, China) and the United Nations Global Geodetic Centre of Excellence (UN-GGCE) were invited to attend as observers.
5. Regarding membership application of Pakistan, which was submitted at the fifteenth meeting of ICG, ICG failed to attain consensus. ICG agreed to continue to work towards a swift conclusion on the matter. A member of ICG appealed to accelerate this process.
6. ICG noted that the working groups had focused on the following issues: systems, signals and services; enhancement of GNSS performance, new services and capabilities; information dissemination and capacity-building; and reference frames, timing and applications.

7. The Working Group on Systems, Signals and Services (Working Group S), through its subgroups and task forces, continued the work outlined in its workplan during the intersessional period between the seventeenth and eighteenth meetings of ICG. Under the leadership of the subgroup on compatibility and spectrum protection, the Working Group continued its campaign to promote adequate protection of GNSS spectrum by reviewing relevant GNSS/Radionavigation satellite Service (RNSS)-related activities of the International Telecommunication Union (ITU). The subgroup conducted a workshop on interference detection and mitigation in April 2024, focused on the aviation and maritime sectors with discussion on existing processes as a possible baseline/reference for other industry sectors using GNSS services that could be used and implemented in their sector interference detection and mitigation strategies. The subgroup also agreed to conduct a twelfth workshop on interference detection and mitigation, to exchange processes to better communicate and disseminate information about GNSS interference incidents across the GNSS user stakeholder community.

8. The subgroup on interoperability and service provision continued to make progress on the work in its workplan, including overseeing the work of its task forces. The precise point positioning (PPP) interoperability task force held a workshop in January 2024 and completed the fourth edition of the PPP/PPP-Real Time Kinematic (RTK) service providers report detailing information about planned service. The International GNSS Monitoring and Assessment (IGMA) task force conducted a workshop focused on discussing plans for the second run of the joint trial project with the International GNSS Service (IGS) data exchange formats. The IGMA task force plans to hold another workshop in 2025 to evaluate the results of the second run of the joint trial project. The performance standards group also continued its work on a "Hints and Tips" document. The IGMA task force and performance standards group plan to continue with combined virtual meetings monthly. Timing experts from the subgroup on interoperability and service provision held a meeting to discuss next steps and agreed to questions and criteria for reaching out to industry for views on timing interoperability. The expert group plans to conduct a workshop to review and share the results of the industry outreach.

9. Under the Working Group's workplan focused on system of system operations, the working group organized a workshop on future low Earth orbit (LEO) positioning, navigation and timing (PNT) systems focused on examining compatibility and interoperability issues and the role of future LEO PNT providers in ICG. The Working Group agreed to a recommendation supporting annual workshops focused on LEO PNT compatibility and interoperability issues. Providers also continued to review feedback on the 2020 report from the Inter-Agency Space Debris Coordination Committee (IADC) that followed a recommendation from the thirteenth meeting of ICG to study the issue of debris mitigation practices relevant to the medium Earth orbit (MEO) and Inclined Geosynchronous orbit (IGSO) orbital regimes used by GNSS. The Working Group plans to hold a small group discussion, led by China and the European Union, to finalize feedback to IADC on the report. Under the topic of system of system operations, the working group received presentations from system providers, who are looking into methods for authentication of open civil signals. Finally, the working group agreed to a recommendation supporting updating its work plan to incorporate the following four topics: PPP interoperability, civil signal authentication, LEO PNT compatibility and interoperability and lunar PNT compatibility issues with GNSS/RNSS.

10. The Working Group on Enhancement of GNSS Performance, New Services and Capabilities (Working Group B) has progressed in its activities. The Working Group B space use subgroup presented its accomplishments since the seventeenth meeting of ICG. Monthly virtual meetings were held to progress on its work plan. The subgroup organized a dedicated space service volume session at the Munich Satellite Navigation Summit in March 2024, including lunar activities, which demonstrated increasing

interest in this topic. The subgroup held a hybrid meeting in June 2024 in Vienna, in which it adopted status definitions for its work plan activities and began discussions towards a third edition of the space service volume booklet. The subgroup work package two on space user profiles and needs presented its progress, including analysis of available mission databases and drafted a space use term list. The subgroup work packages one, three and five, currently in dormant status, indicated their intentions to return to active status in the next year.

11. The space use subgroup work package 4 on GNSS space service volume and lunar PNT reviewed progress on planning for the joint ICG-Interagency Operations Advisory Group (IOAG) multilateral cislunar PNT workshop, which was initiated as a recommendation at the seventeenth meeting of ICG. Active planning is under progress by the organizing committee. The workshop is planned to be held on 11 - 13 February 2025 in Vienna, with both in-person and broadcast attendance options. Registration is now open at the ICG information portal[1] and will close on 22 November 2024. The subgroup encourages all members of ICG to participate in this workshop.

12. The space use subgroup provided an update on the successful joint working group session on Lunar PNT held in June 2024 in Vienna. The session received 14 presentations from lunar PNT provider agencies and international organizations on the topics of systems, spectrum, reference frames, timing, GNSS lessons learned, and lunar PNT within ICG. During the session, the need was identified to establish a centralized, dedicated working group within ICG at the earliest opportunity in order to continue the active and necessary coordination among the lunar PNT community, without affecting the scope and work of the existing Earth-focused working groups. The subgroup presented the proposed recommendation and initial work plan as a reference for the ICG Working Group L on Lunar PNT, which had received support of the Working Group B for endorsement by ICG.

13. Since the seventeenth meeting of ICG, the Working Group B application subgroup had made significant progress on its initiative entitled “GNSS applications: for present and future”. The subgroup’s current activities focus on studying cases of operational GNSS applications that were in the market or were under final development before market release. The subgroup was finalising the research report entitled “GNSS applications for sustainable development: case studies”, which intended to provide assistance and guidance to GNSS users based on lessons learned. The co-chairs expressed their gratitude for the contributions received from China, India, Japan, the United States of America and the European Union and encouraged the continued proactive support from all providers to ensure the release of the first issue by early 2025.

14. The Working Group recognised the significance of the increasing solar activity in the current 25th solar cycle on GNSS services and satellites. To better understand the potential effects of space weather events and the necessity for international data sharing in support of monitoring and notification activities, further expert discussions were needed. The formation of a task force under the umbrella of the Working Group B would be considered in a dedicated workshop focused on the impact of solar activities on GNSS and their usage. In line with the new recommendation, the Working Group will organise the workshop during the 2025 intersessional meeting. Providers and members of ICG were encouraged to actively support the planned workshop with expert contributions.

15. During the Working Group B meeting presentations were made on the varied topics such as GNSS applications, space weather, GNSS reflectometry, LEO PNT and lunar PNT systems.

[1] https://www.unoosa.org/oosa/en/ourwork/icg/working-groups/b/CislunarPNT2025.html

16. In preparation of the nineteenth meeting of ICG, Working Group B planns to revise its workplan endorsed at the tenth meeting of ICG to reflect the evolved scope of the Working Group activities and to identify new work topics of relevance to ICG members and providers. The workplan revision would be the main subject for the intersessional meeting in 2025. All members of the working group were invited to revise the current workplan and identify potential work areas in preparation of the intersessional meeting. Relevant technical contributions to support the discussion of the Working Group workplan were welcomed.

17. The Working Group on Information Dissemination and Capacity-building (Working Group C) addressed all areas of its workplan. Representatives of Australia, China, India, Italy, Japan, New Zealand, Norway, the Republic of Korea, the United States of America, as well as the European Union and the European Space Agency participated in the work of the Working Group. Presentations on GNSS education programmes, resources and activities carried out by the respective organizations were made. The Working Group also received an update on the activities undertaken or supported by the Office for Outer Space Affairs during 2024 and to be carried forward into 2025 with a continued focus on training for capacity building; promoting the use of GNSS technologies as tools for scientific applications; regional workshops on applications; and information dissemination.

18. The Working Group noted continued training for capacity development through the international delivery of various GNSS training programmes, including in supporting developing countries through scholarships offered. It was recognised that scholarships for these GNSS training courses might be enhanced by individual countries and companies sponsoring individuals. The Working Group further discussed the balance between in-person, online and hybrid modes of training delivery, with a preference for in-person due to the benefits of networking and informal mentoring and/or the hands-on requirements of the coursework, such as fieldwork to GNSS sites or understanding receivers and devices. Recognising the benefits of in-person attendance and to further increase capacity development within regions, the Working Group encouraged the United Nations-affiliated Regional Centres to connect with the ICG experts to deliver training courses at the Centres. The Working Group further encouraged exploration of a train the trainers programmes by regional centres whereby they could identify and support the development of in-region qualified trainers. Recognising the importance of information sharing and dissemination, the Working Group supported engagement between the regional centres to share training materials and the exchange of lecturers.

19. The Working Group noted an update by the Working Group's project team on space weather monitoring using low-cost GNSS receiver systems, led by the Office for Outer Space Affairs, and consisted of experts representing the Abdus Salam International Centre for Theoretical Physics (Italy), Boston College (United States), the University of Tokyo (Japan) and the Laboratory of Plasma Physics (France). It was noted that the project had continued to achieve results of a comparison between the low-cost receivers and the scientific-grade instruments demonstrating that the tested low-cost receiver could be used for ionospheric total electron content monitoring and related studies. The project team would further explore whether ionospheric modelling and the analysis of space weather effects such as scintillation parameter (S4) could also be computed. It was noted that the project team was invited to form the working group under Commission 4 - Positioning and Applications in the International Association of Geodesy (IAG).

20. The Working Group recognised various activities supporting GNSS science applications, including through other working groups and multi-lateral forums. In particular, the Working Group was invited to collaborate with international initiatives that offer capacity building programmes and applications, such as newly established

Antarctic Geospace and ATmospheric research (AGATA) scientific research programme under the Scientific Committee for Antarctic Research and others.

21. The Working Group on Reference Frames, Timing and Applications (Working Group D) noted progress on the geodetic and timing references by the GNSS and RNSS providers and thanked the providers for their continued efforts. The Working Group encouraged all providers to continue to review and update accordingly their templates on geodetic and timing references, and to make these available on the ICG information portal.

22. The IGS Real-Time Committee presented an update on its real-time service and recent activities. The IGS real time service provides real-time corrections for all four main constellations, clock corrections being of particular interest for the Working Group. IGS noted a desire to increase collaboration with system providers to improve the IGS real-time tracking network, particularly in Africa and large parts of Asia, and to strengthen the IGS real-time data infrastructure in view of the increase in the number of user requests.

23. In a joint working groups discussion, the United Nations Global Geodetic Centre of Excellence (UN-GGCE) highlighted weaknesses in the global geodesy supply chain[2]; in particular, issues relating to the reliability of geodetic products such as Earth Orientation Parameters (EOP) and future realisations of the International Terrestrial Reference Frame (ITRF), which were essential to the operation of GNSS satellites. ICG members openly acknowledged the risks highlighted by UN-GGCE and recognized strengthening the global geodesy supply chain should be prioritised to ensure GNSS services are more robust.

24. The Working Group timing references task force reviewed the past Working Group's recommendations (11, 16-A, 19, 20, 21, and 27) for GNSS timing templates on redefinition of Coordinated Universal Time (UTC), rapid UTC (UTCr), offset between GNSS times and naming conventions. Recommendations 11, 19, 20, 21-B were on-going. Recommendation 16-A was addressed by the 2022 General Conference on Weights and Measures Resolution 4. Recommendation 27 did not have any specific item open for updates. The timing references task force continues to encourage system providers to update their GNSS timing templates on the ICG information portal. The task force thanked India for updating the NavIC timing template in 2024.

25. The International Bureau for Weights and Measures (BIPM) provided updates on the new section 4 circular T that publishes the difference between UTC and the bUTC_GNSS. BIPM reported an improvement of the processing chain that now features a pool of UTC G1 labs, each of them providing calibrated multi-GNSS observations that are then combined by BIPM. Details are published in (10.1088/1681-7575/ad0562) and results are available through an updated application programmatic interface[3] and online[4] respectively.

26. BIPM reminded ICG about the work towards a continuous UTC, also done in collaboration with the International Earth Rotation and Reference Systems Service (IERS). BIPM also reminded that ITU endorsed a continuous UTC during the World Radiocommunication Conference (WRC-23) in November 2023. BIPM started a survey among GNSS providers to assess the impact of the forthcoming Universal Time (UT1)-UTC tolerance increase, and to gather potential preferred values for the maximum tolerance; responses were received from the United States' global positioning system

[2] The global geodesy supply chain refers to ground observatories (VLBI, SLR, GNSS, DORIS and gravity); data centres; analysis, correlation, and combination centres; and the development of geodetic products including TRFs and EOPs (https://ggim.un.org/UNGGCE/).

[3] https://webtai.bipm.org/api/v1.0/

[4] https://webtai.bipm.org/database/canvas_gnss.html

(GPS), the Russian Federation's global navigation satellite system (GLONASS), the European Union's global navigation satellite system (Galileo), China's BeiDou satellite navigation system (BDS), and India's NavIC.

27. BIPM noted that a negative UTC leap second might become necessary in the near future and acknowledged that this might create a risk of disruption. BIPM urged ICG members and GNSS providers to consider the unprecedented possibility of a negative leap second and its broader impact. Some BIPM member states asked for the implementation of continuous UTC before 2035 to avoid the risk of a negative leap second. Unfortunately, the limited knowledge and models on the Earth rotation do not allow an accurate forecast of UT1-UTC in the long term.

28. The French National Space Agency (CNES) presented Galileo and the European Geostationary Navigation Overlay Service (EGNOS) Monitoring Of Performances (GEMOP), whose goal was to monitor the Galileo Open Service and EGNOS services (open service, safety-of-life, EGNOS data access service, time), in particular the Galileo System Time. GEMOP results show that the Galileo timing requirements were met with a large safety margin.

29. The Working Group noted the willingness of India to include NavIC time in the BIPM Circular T Section 4. As ICG cannot take decisions on the BIPM work, BIPM recommended NavIC representatives to establish contact with the consultative committee for time and frequency (CCTF) for that purpose. The Indian Space Research Organization (ISRO) reported that a NavIC-capable receiver was sent and deployed in the National Metrology Institute (Germany) for testing and calibration. Efforts are ongoing to establish NavIC-capable receivers at other UTC G1 labs, with agreements currently under discussion with Italy and France.

30. The European Space Agency (ESA) reported on the development of operating tools to monitor GNSS timing systems and to perform receiver calibrations. Routine calibrations are performed yearly, with a set (non-changing) procedure; sequential calibrations show good stability as a function of time.

31. The European Space Research and Technology Centre (ESTEC) offer state-of-the-art facilities and tools for the monitoring of multi-GNSS timing performances. These resources are available to ICG members interested in conducting calibration tests or participating in campaigns.

32. ESA reported a new cross-support agreement between ESA and ISRO, focused on network operations and calibration facilities. Two GNSS timing receivers supplied by ISRO will be calibrated by ESA, and the calibration report will be shared with ISRO. These receivers will be used as references for NavIC timing, and ISRO will broadcast the calibrated time offset through the NavIC system.

33. China reminded the Working Group about the UTC Pivot methodology and provided time offsets results for different constellations. The National Time Service Centre of China showed that the deviation from UTC of the reference time UTC(k) involved in the GNSS timekeeping is getting smaller. This is beneficial for the application of the UTC Pivot method.

34. The Working Group geodetic references task force hosted seven presentations, focusing mostly on updates regarding several global and regional reference frames. The task force wishes to commend ESA's efforts on the GENESIS (ESA's Navigation Mission) project and to highlight the value of this mission.

35. The International Federation of Surveyors (FIG) has released the 2024 edition of the Reference Frame in Practice Manual[5], building on the 2014 edition with inputs from

[5] https://fig.net/resources/publications/figpub/pub64_2ed/Figpub64_2ed.pdf

the IGS and UN-GGCE. Announced after the FIG Working Week 2024, it includes updates on global geodesy initiatives, GNSS constellations and processing methodologies. FIG welcomes feedback from providers and opportunities for future collaboration in either next edition and/or technical report on cost-effective GNSS.

36. The Shanghai Astronomical Observatory (SHAO) of China provided transformation parameters between the BeiDou Coordinate System (BDCS) and ITRF14 and ITRF20, reporting millimetre-level agreement on the alignments. SHAO also provided updates and recent results on the satellite laser ranging tracking of BDS satellites, highlighting the value of this effort for validating GNSS ephemerides and improving solar radiation pressure models and antenna phase centre offsets.

37. ESA reported that the Galileo terrestrial reference frame (GTRF), a high-accuracy realisation of ITRF, continues to be developed. ESA is working towards a requirement better than 3 cm to ITRF and reported that GTRF will be updated and published in the next few months.

38. ESA reported that the GENESIS mission will be launched in 2028, with an initial operation period of two years. GENESIS will be managed by ESA's navigation team and involve industry partners for satellite development, launch, operations, and data acquisition. To ensure coordination, five working groups have been established, one dedicated to ITRF and combined solutions, and four for each observation technique (GNSS, very long baseline interferometry (VLBI), satellite laser ranging (SLR), and the Doppler Orbitography and Radio-positioning Integrated by Satellite instrument (DORIS)). ESA emphasised the importance of the VLBI working group due to the fact that VLBI stations around the globe will need to start tracking GENESIS's VLBI transmitter. ESA has also issued a call for international collaboration to help achieve the mission's objectives and highlighted the importance of collaborating with the science community *via* the five working groups.

39. The National Geospatial-Intelligence Agency of the United States of America reported the release of a new realisation (G2296) of the World Geodetic System 1984 (WGS84) terrestrial reference frame and provided a comprehensive report to the Working Group. The new release is aligned to both ITRF2020 and IGS20, and remains a linear frame defined by station positions and velocities. WGS84 (G2296) improves the estimation technique by fitting both an annual and semi-annual signals to the time series. These improvements introduce enhanced means to handle station discontinuities due to antenna movements, including post-seismic deformation terms after a significant earthquake. In addition, the new realisation adopts the antenna phase centre offsets for the entire GPS constellation as provided by the IGS20 ANTEX (the Antenna Exchange Format) file.

40. ISRO reported interest in establishing a widespread network with multi-frequency NavIC (L1, L5 and S bands) tracking capabilities. ISRO offered to support station operators to either augment existing infrastructure or establish new stations. ISRO is developing a GNSS Data and Analysis Center to generate and disseminate NavIC precise products.

41. The Russian Federation continues to develop its geodetic infrastructure noting two additional GNSS stations were installed during the last year following IGS station specifications guidelines. The working group expresses its thanks for operators, who follow IGS guidelines in upgrading / installing new stations.

42. The Russian Federation reported on annual coincidence and monthly repeatability results between different terrestrial reference frames between 2021 and 2024. According to the results of analysis, the agreement between WGS84 and ITRF2020 is assessed as 1 - 4 cm, the BeiDou Coordinate System (BDCS) -– 3 - 4 cm, and GTRF – 2 - 5 cm; Parametri Zemli (PZ-90.11) is at the level of 10 cm according to the

GLONASS technical requirements. The best terrestrial reference frames repeatability performance was found for both GTRF and WGS84 (around 5 cm), while BDCS and PZ-90.11 showed discrepancies up to 7 and 12 cm respectively.

43. The Working Group Applications of GNSS for Disaster Risk Reduction Task Force noted a welcome increase in ICG activities related to the integration of GNSS data in disaster risk reduction strategies, especially during the Applications and Experts Seminar. The task force thanks the on-going efforts of the "GNSS enhancement to Tsunami Early Warning Systems (GeTEWS) Oceania" working group in developing interactions and relationships in Oceania.

44. Recognising the need for more extensive outreach and advocacy on the role of GNSS in natural hazard monitoring, the task force has drafted a policy brief to clearly articulate the benefits of GNSS in disaster risk reduction and encourage the uptake of GNSS technology among stakeholders and policymakers. The Working Group approved the policy brief and recommended that ICG publish it.

45. The Working Group held internal discussions on the topic of Lunar PNT and participated actively in the subsequent working groups joint session. The Working Group noted that these discussions could be extended to other celestial bodies.

46. The Working Group highlighted the importance of relating the existing (Earth) reference frames to lunar reference frames, and the careful consideration of the point of transition and transformation parameters between reference frames.

47. The Working Group noted the need for further research on the potential for joint services between Earth-based GNSS and Lunar PNT, noting that the reference frames services provided at present by Earth-based GNSS do not fully meet the needs of a joint service covering both the Earth and the Moon. The Working Group welcomed collaboration around these activities.

48. BIPM recommended that any time scale on the Moon (and other celestial bodies) has a clear and traceable connection to UTC, and that the work be carried out in close collaboration with the relevant international organisations. Relevant organisations should at least include the International Astronomical Union (IAU), the International Association of Geodesy (IAG), ITU and the Consultative Committee for Time and Frequency (CCTF)-BIPM. BIPM provided a list of commissions, task forces, and working groups that are relevant to the upcoming efforts on Lunar PNT.